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(54) **HEATSINK APPARATUS FOR DE-COUPLING CLAMPING FORCES ON AN INTEGRATED CIRCUIT PACKAGE**

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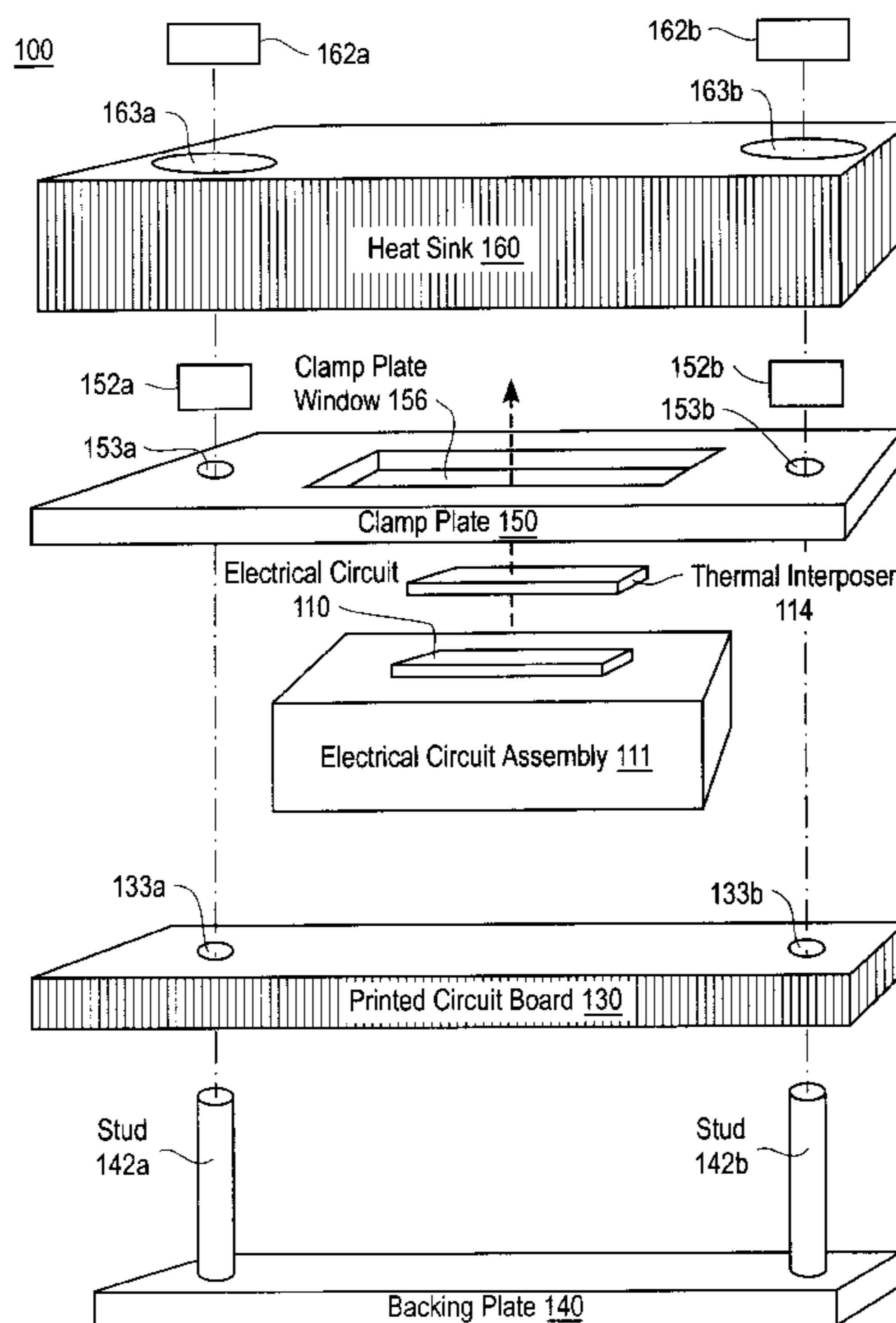
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(57) **ABSTRACT**

A clamping system decouples the clamping forces in an electrical circuit assembly coupled to a heatsink. A heatsink clamping assembly applies controllable and predictable force on the electrical circuit assembly including an integrated circuit device (“chip”). The applied force is controlled to effectively ensure intimate contact between the chip and the heatsink to facilitate efficient chip cooling. The force applied to the chip is decoupled from the much higher force required to clamp the electrical interposer interconnect structure between the electrical circuit assembly and the printed circuit board.

46 Claims, 4 Drawing Sheets



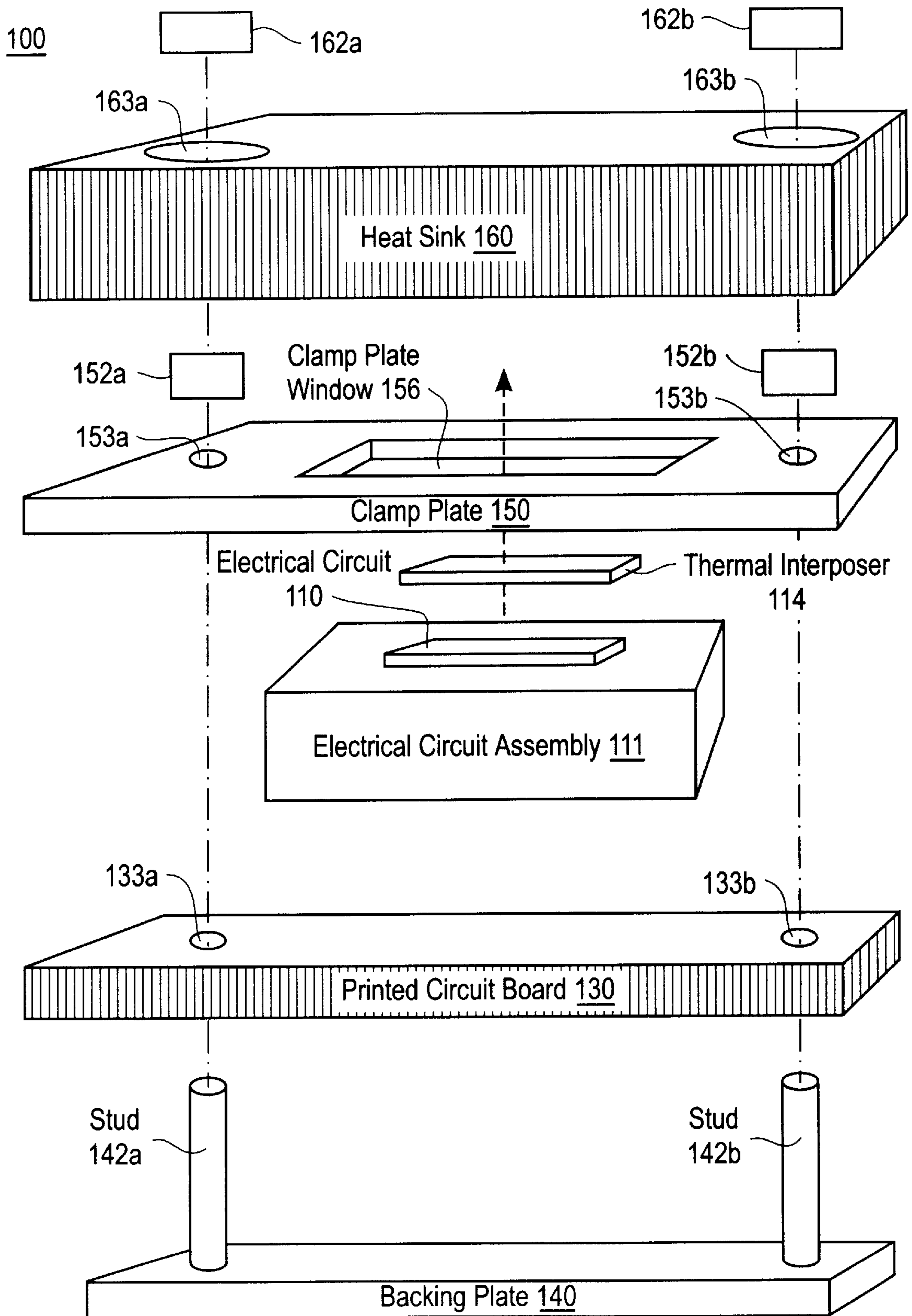


FIG. 1A

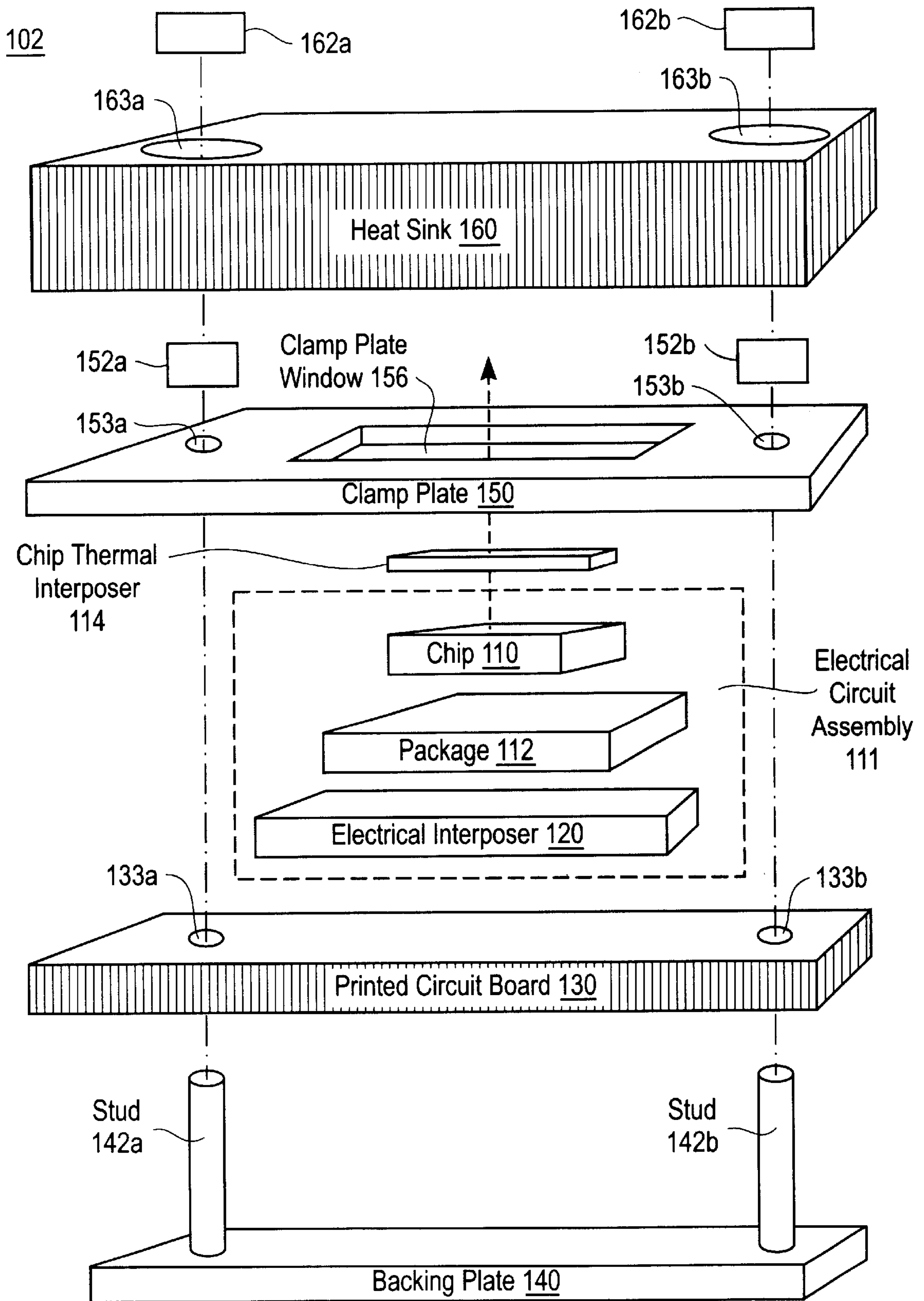


FIG. 1B

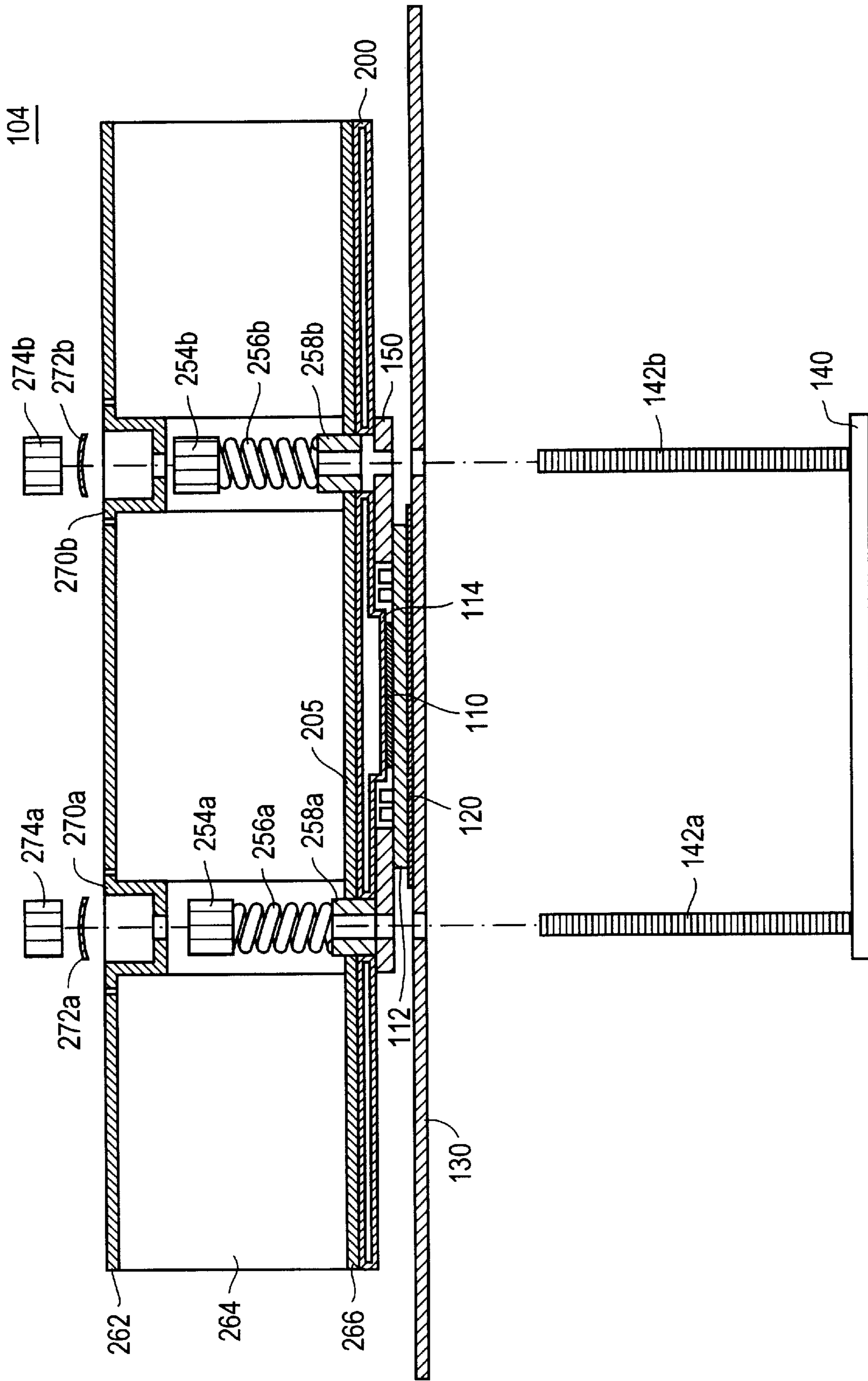


FIG. 2

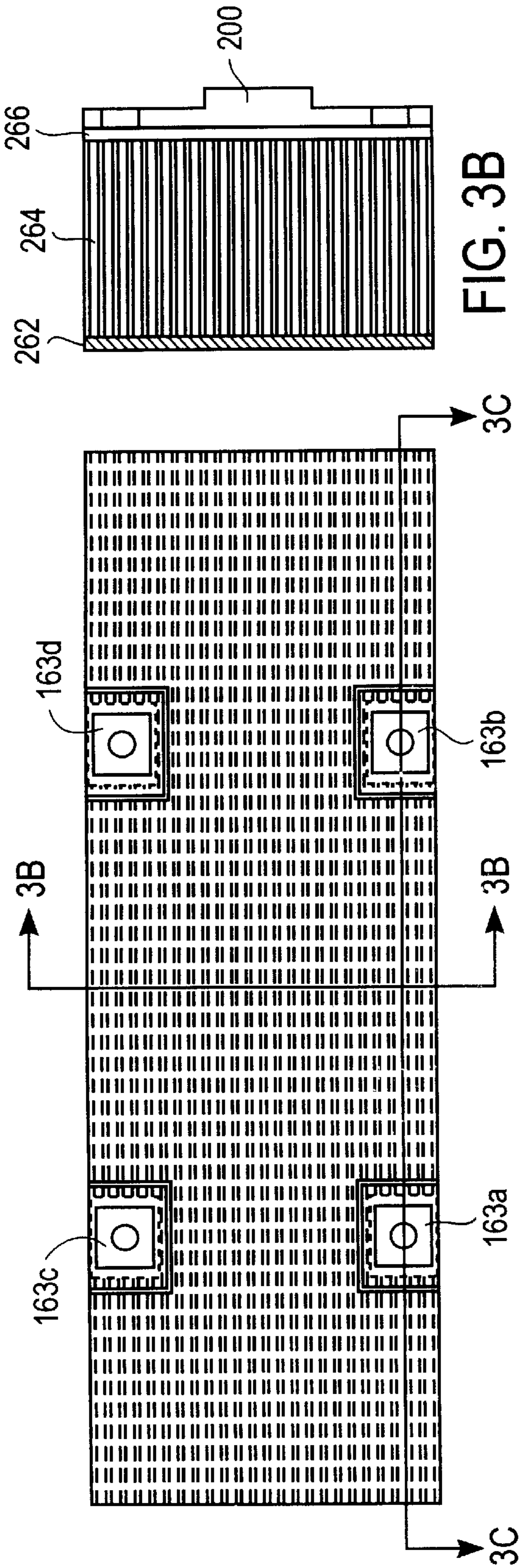


FIG. 3B

FIG. 3A

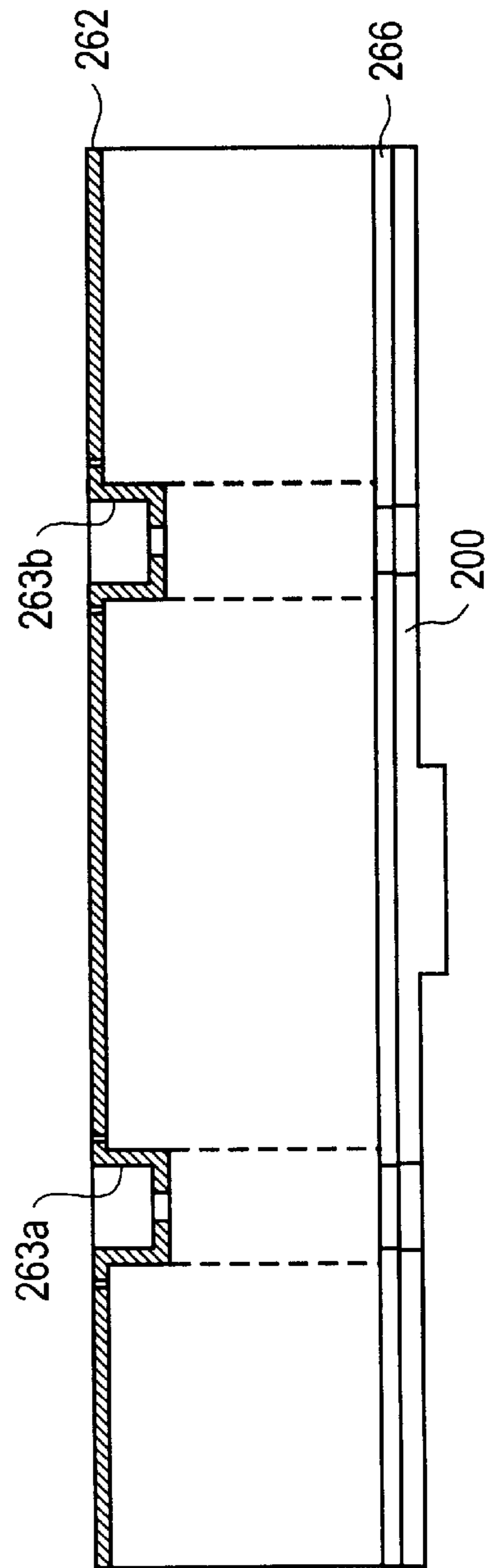


FIG. 3C

HEATSINK APPARATUS FOR DE-COUPLING CLAMPING FORCES ON AN INTEGRATED CIRCUIT PACKAGE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a system for attaching a heatsink to an integrated circuit device, and more particularly, to a system for clamping a heatsink to an integrated circuit device that applies controllable force onto the integrated circuit device.

2. Description of the Related Art

The use of integrated circuits is becoming more prevalent every day. Integrated circuits (ICs) are used in a multitude of different devices from household appliances to computer applications. However, ICs are also rather fragile. They are generally thin pieces of silicon on which circuits are constructed. These IC "chips" are subject to corrosion, environmental damage, physical shocks, and other damage mechanisms. For this reason, IC chips are packaged using a variety of different materials and package styles to protect them from possible damage during transportation and use.

Conventional protective packaging is generally a plastic or ceramic material used as a base for the IC chip and serving as a means of expanding ("fanning out") the electrical connections of the IC chip. The connections between the IC chip and the package are typically accomplished using wire bonds or, in the case of "flip chip," solder balls. In a "flip chip" arrangement, the top of the IC chip is flipped over face down onto the base package. Solder balls placed between the face of the chip and the base package provide electrical connections between the chip and the base package. Additionally, a lid may be attached over the IC to provide protection for the chip. The choice of protective packaging will be determined by various factors including the parameters of the chip itself, the IC application, and the packaging material cost.

In addition to providing chip protection, a component is also needed to allow the chip and package to make electrical connections to other devices. These connection components function as electrical components, with circuits that connect the chip to the Printed Circuit Board (PCB) or other device to which the chip is attached.

There are several different types of connection components allowing a chip and package to make electrical connections to a PCB. The selection of the appropriate electrical connection component will depend to a large extent upon the particular design of the chip itself, the number of connections required, and the size of the package. For example, for connections with a chip encased in a protective package that is no larger than 32 mm square (1.59 in²) area, an array of solder balls (a ball grid array package or "BGA") may be used to make the electrical connections. Similarly, for packages no larger than 42 mm square (2.73 in²) area, an array of solder columns (a column grid array package or "CGA") may be used to make the electrical connections. Both the ball and column grid arrays can be directly soldered to a PCB.

Both the ball and column grid array methods have a size limitation stemming from the long-term reliability of the connection. This limitation is mainly a function of the coefficient of thermal expansion (CTE) mismatch that typically exists between the IC package construction material and the PCB construction material. As a package gets larger

the outermost connections from the center of the package may be stressed beyond their yield point as the IC chip heats the package. Therefore, for larger chips with a high lead count, or for more durable chip package systems, it is preferable to use an interposer component. An interposer provides an array of compressible contact points, such points being comprised typically of a polymer with imbedded electrically conductive metal or comprised of a metal spring structure. The required electrical connection is accomplished through contact pressure rather than a rigid bond. By being a compliant connection the interposer thus effectively decouples heat expansion stresses that can occur between the package and the PCB. However, when using an interposer to provide an electrical connection between a packaged IC and a PCB, considerable pressure must be applied to ensure a good low resistive electrical contact connection is achieved.

Certain IC chips also require the capability to dissipate a large amount of heat energy. For example, some high-powered chips may give off over 100 watts of heat energy. For such high-powered chips, the cooling provided by ambient air is not sufficient to prevent the chip from overheating. An additional component for removing the heat from the chip is required. A heatsink is commonly attached to an IC chip package, with a thermal interposer material in-between, in order to provide superior heat dissipation. The thermal interposer provides good thermal conductivity between the device and heatsink. In a conventional system, the heatsink may be attached, with a thermal interposer material in-between, to the package lid protecting the chip, or if no lid is used, directly to the chip itself.

The entire assembly consisting of the heatsink, the thermal interposer, the chip, the base package, and the electrical connection components, is clamped together to ensure proper electrical connections and heat transfer capabilities. Significant clamping force (often exceeding several hundreds of pounds) is required to clamp the chip-package-interposer-PCB arrangement tightly enough to ensure a proper electrical connection through the interposer. The heatsink-to-chip connection does not require a similar clamping force to provide heat transfer capability. However, because the entire assembly is clamped together when a conventional heat sink structure is used, all components are subjected to the same clamping force. This clamping force could damage the chip itself, even though a lid may be used, since the lid could compress into the underlying chip.

In the conventional packaged chip and heatsink arrangement where the chip is covered by a lid, the heatsink and thermal interposer do not contact the chip directly. Heat must pass through the air layer or other conductive layer between the chip and the lid, as well as through the lid itself, and the thermal interposer, before being dissipated by the heatsink. Such an arrangement makes it difficult to effectively cool certain high-powered chips. A preferable arrangement is to provide contact directly between the heatsink and the chip itself. This arrangement provides for superior heat transfer properties. However, without a lid present to absorb some of the compressive forces, extreme care must be taken to ensure that the chip is not crushed in this situation due to the clamping force required for the rest of the assembly.

Thus a high-powered chip packaging assembly that includes both a heatsink and an electrical interposer has two different, competing clamping force needs. Significant clamping force is required for achieving proper connections in the chip-package-electrical interposer-PCB portion of the assembly. However, significantly less clamping force is

desirable between the chip-thermal interposer-heatsink assembly, to avoid damaging the chip. Thus, there is a need for a system that decouples the clamping forces between these two sections of the overall assembly.

SUMMARY OF THE INVENTIONS

The present invention provides a system that decouples the clamping force in an electrical circuit assembly coupled to a heatsink. A heatsink clamping assembly applies controllable and predictable force on the electrical circuit assembly including a packaged microelectronic integrated circuit device ("chip"). The applied force is controlled to effectively ensure intimate contact between the chip and the heatsink to facilitate efficient chip cooling. The force applied to the chip is decoupled from the much higher force required to clamp the interposer interconnection between the electrical circuit assembly and the printed circuit board. There are certain instances where the base of the heat sink may be a hollow chamber or heat pipe structure, and as such could be damaged if the full clamping force were required to be imposed.

In one embodiment, a heatsink clamping assembly comprises an electrical circuit assembly electrically connected to a printed circuit board (PCB). The electrical assembly includes an electrical circuit. A backing plate coupled to studs contacts the PCB, and the studs extend through apertures in the PCB. A clamp plate with a window contacts the edges of the electrical assembly while allowing the electrical circuit to pass through the window. The studs pass through the clamp plate, and a first pair of clamp nut assemblies clamps the electrical circuit assembly and PCB between the backing plate and the clamp plate.

A heatsink contacts a thermal interposer on top of the electrical circuit, and resides slightly above the clamp plate. The studs extend through the heatsink. A second pair of clamp nut assemblies connects the heatsink to the backing plate. The force used upon the first and second pairs of clamp nut assemblies may differ, thereby decoupling the two forces.

In one embodiment, the electrical circuit assembly comprises an electrical circuit, a package electrically coupled to the electrical circuit, and an electrical interposer electrically coupled to the package. The electrical interposer provides an electrical connection to the PCB. In one embodiment, the electrical circuit is an integrated circuit flip chip.

The features and advantages described in the specification are not all-inclusive, and particularly, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims hereof. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and may not have been selected to delineate or circumscribe the inventive subject matter, resort to the claims being necessary to determine such inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is an exploded three-dimensional view of the elements of a clamping assembly for an integrated circuit with a heatsink in an embodiment of the present invention.

FIG. 1B is an exploded three-dimensional view of the elements of a clamping assembly for an integrated circuit with a heatsink in another embodiment of the present invention.

FIG. 2 is a cut-away view of the layers of a clamping assembly for an integrated circuit with a heatsink in an embodiment of the present invention.

FIGS. 3A–3C are a top view of a heatsink and two vertical sliced views of the heatsink in an embodiment of the present invention.

The figures depict a preferred embodiment of the present invention for purposes of illustration only. One skilled in the art will readily recognize from the following discussion that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the invention described herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to several embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever practicable, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

FIG. 1A is an exploded view of the components in an embodiment of a clamping assembly **100**. Clamping assembly **100** includes an electrical circuit assembly **111**, a printed circuit board ("PCB") **130**, a backing plate **140**, a clamp plate **150**, a thermal interposer **114**, and a heatsink **160**. Clamping assembly **100** has a first clamped group of components and a second clamped group of components, wherein the first and second groups may be clamped together using different amounts of force.

The first clamped group of components includes the electrical circuit assembly **111**, the PCB **130**, the backing plate **140** and the clamp plate **150**. Electrical assembly **111** includes an electrical circuit **110**; however, no clamping force is applied to the electrical circuit **110** within the first clamped group of components. Backing plate **140** is connected to two studs **142A** and **142B**. PCB **130** includes two apertures **133A** and **133B**, dimensioned to allow the studs **142** to pass through. Clamp plate **150** includes two apertures **153A** and **153B**, dimensioned to allow the studs **142** to pass through. Clamp plate **150** also includes a clamp plate window **156**, which runs through the clamp plate **150**, and is dimensioned to fit around the electrical circuit **110** and prevent the electrical circuit **110** from being subjected to the clamping force applied to the first clamped group of components. A pair of clamp nut assemblies **152A** and **152B** clamp onto the studs **142** above the clamp plate **150**, and may be adjusted to provide the first clamped group of components with the desired clamping force.

The electrical circuit assembly **111** and the PCB **130** must be mated together tightly in order to assure a good electrical connection between their components. Typically, a force of approximately 60–80 grams per contact (0.13–0.18 pounds per contact) is required to assure proper electrical contact. This translates into a stud **142** clamping force of approximately 90–120 kilograms force (190–260 pounds force). Because the electrical circuit **110** passes through the clamp plate window **156**, this force is not applied to the electrical circuit **110**.

The second clamped group of components clamps the electrical circuit **110** to the heatsink **160**, with the thermal interposer **114** in-between. The heatsink **160** includes two apertures **163A** and **163B**, dimensioned to allow the studs **142** to pass through. A pair of clamp nut assemblies **162A** and **162B** clamps onto the studs **142** above the heatsink **160**, and may be adjusted to provide the second clamped group of components with the desired clamping force.

The clamp plate **150** is dimensioned to approximately match the thickness of the electrical circuit **110**. Thus, when the heatsink **160** is clamped on top of the clamp plate **150**,

the heatsink **160** contacts both the clamp plate **150** and the electrical circuit **110**, with the thermal interposer **114** in-between, and provides a thermal conducting connection for removing heat from the electrical circuit **110**. Maintaining a proper thermal conducting connection requires significantly less clamping force than the electrical connection between the PCB **130** and the electrical circuit assembly **111**. A stud **142** clamping force of approximately 4.5–6.8 kilograms force (10–15 pounds force) is applied to the second clamping group to provide a good thermal conduction connection between the heatsink **160** and the electrical circuit **110**.

The backing plate **140** and the clamp plate **150** are composed of a rigid material. In one embodiment, the backing plate **140** and the clamp plate **150** are composed of steel. Heatsink **160** is composed of any highly thermally conductive material, for example, aluminum, copper, or even some impregnated polymer material. In some cases, a combination of materials are used, for example: aluminum for the heat sink fin structure and copper for a heat sink base or heat sink base heat pipe. The studs **142** and nut clamping assemblies **152** and **162** are composed of a rigid material capable of carrying a significant clamping force.

The dimensions of the PCB **130**, backing plate **140**, clamp plate **150**, thermal interposer **114**, and heatsink **160** are dependent upon the size of the electrical circuit **110** and the electrical circuit assembly **111**. The PCB **130**, backing plate **140**, clamp plate **150** and heatsink **160** are all dimensioned to have a surface area large enough to accommodate apertures surrounding the electrical circuit assembly **111** to allow the studs **142** to pass through for clamping. The studs **142** are dimensioned to be sufficiently long enough to pass through the PCB **130**, electrical circuit assembly **111**, clamp plate **150**, thermal interposer **114**, and heatsink **160** and connect to the clamp nut assemblies **152** and **162**.

FIG. 1B is an exploded view of the components in another embodiment of a clamping assembly **102**. Clamping assembly **102** similarly contains a first and a second clamped group of components as described regarding clamping assembly **100**. However, in clamping assembly **102**, the electrical circuit is an integrated circuit (“IC”) chip **110**. The electrical circuit assembly **111** is a package **112** and an electrical interposer **120**. Clamping assembly **102** decouples the force applied to the first clamped group of components (package **112**, electrical interposer **120**, PCB **130**, backing plate **140**, and clamp plate **150**) from the force applied to the second clamped group of components (IC chip **110**, chip thermal interposer **114**, and heatsink **160**).

Package **112** holds and protects the IC chip **110** and provides electrical connections to the chip **110**. The electrical interposer **120** provides an electrical connection between the IC chip **110** connections (through the package **112**) and the PCB **130**. Clamping assembly **102** further includes a chip thermal interposer **114**, which provides a thermal conducting layer between the chip **110** and the heatsink **160**.

Clamping assembly **102** is designed for the particular needs of chips that have the following characteristics: (1) they are high-wattage chips, typically greater than 100 watts, and (2) they have high electrical interconnect counts, requiring relatively large chips, typically 20 mm square (0.62 in²) in area or larger. High-wattage chips typically generate too much heat to use a lidded package configuration, and it is preferable to attach a heatsink directly onto the back of the chip through a thermal interposer. Large chips require large packages, and as discussed previously, an electrical interposer **120** is more suitable than ball or column grid arrays for

providing larger IC chip packages with electrical connections to a PCB.

Thus IC chip **110** is typically a high-wattage chip emitting approximately 100 watts or more, and is typically 20 mm square or larger in size. However, it will be evident to one of skill in the art that the clamping assembly of the present invention may be used with smaller IC chips of lower wattage. In order to further protect the IC chip **110**, and improve the heat transfer capabilities between the IC chip **110** and the heatsink **160**, clamping assembly **102** includes the chip thermal interposer **114**. Chip thermal interposer **114** may be a layer of a conductive material such as silicone grease or a thermal epoxy that coats the IC chip **110**.

The IC chip **110** is attached to the package **112**. The package **112** may be one of a number of different types of IC chip packages. In one embodiment, a “flip chip” type of IC chip **110** and package **112** is used. In a “flip chip,” the IC chip **110** is flipped over onto the package **112** so that the bond pads on the top of the IC chip **110** are directly above the top of the package **112**, which contains a footprint of the IC chip **110** electrical connections. The bond pads between the IC chip **110** and package **112** have solder balls bonded to them that form physical and electrical connections between the IC chip **110** leads and the package **112**.

In one embodiment, package **112** is composed of a ceramic material. In another embodiment, package **112** is composed of a plastic or laminate material. The size of the package **112** is determined by the size of the IC chip **110**. Package **112** is dimensioned to be larger in area than the IC chip **110**, allowing a portion of the package **112** to provide surface contact with the clamp plate **150** as the IC chip **110** passes through the clamp plate window **156**. In one embodiment including an IC chip of approximately 20 mm square, the package size is approximately 45 mm square (3.14 in²) area or larger. It will be evident to one of skill in the art that a smaller package may be used if a smaller IC chip is used.

The electrical interposer **120** provides an electrical connection between the package **112** and the PCB **130**. The electrical interposer **120** consists of a sheet of carrier material that captures an array of compressible conductive buttons that have pieces of electrically conductive material embedded within them to connect leads on the package **112** to leads on the PCB **130**. In one embodiment, the membrane material is a polyamide film. In another embodiment, a ceramic or polymer frame contains an array of spring-like structures typically made of gold-plated or silver-plated beryllium, copper, molybdenum, or similar metals. The electrical interposer **120** is sized to be as large or slightly larger than the package **112**. Thus, for a package size of approximately 45 mm square, the electrical interposer size will be approximately 50 mm square. The dimensions of the PCB **130**, backing plate **140**, clamp plate **150** and heatsink **160** are dependent upon the size of the IC chip **110**, the package **112**, and the electrical interposer **120**.

In one embodiment, the heatsink **160** includes a heat pipe that thermodynamically connects to the IC chip **110** through the chip thermal interposer **114**. A heatsink **160** including a heat pipe typically provides superior heat transfer properties compared to the heatsink alone. A heat pipe is a block of a conductive metal, such as copper, with a hollow cavity inside. The cavity is airtight and maintained at a partial vacuum, and contains a fluid selected for its boiling temperature. Water is often selected for the fluid, as are various alcohols. Heat contacting one side of the heat pipe vaporizes the water within the partial vacuum, and the vapor transfers heat to the heat sink side of the heat pipe where it condenses.

In this manner, heat is spread over the base of the heat sink very efficiently, as the heat pipe wicks heat away from the IC chip **110** and transfers it to the heatsink **160**.

A heat pipe is hollow and therefore somewhat fragile. However, because the clamping assembly **102** decouples the clamping force applied to the heatsink **160** from the clamping force applied to the other components, a low clamping force loading on the heat pipe may be achieved as necessary.

FIG. **2** is a cut-away view of the layers of another embodiment of a clamping assembly **104** for an electrical circuit with a heatsink. The heatsink of clamping assembly **104** includes a heat pipe **200**. The backing plate **140** and studs **142** are shown separated from the rest of the clamping assembly **104**. When clamping assembly **104** is fully assembled, the backing plate **140** contacts the PCB **130** and forms the bottom layer of the clamping assembly **104**.

Moving from the bottom to the top of the clamping assembly **104**, the following components comprise a first group of clamped components: the backing plate **140** contacts the PCB **130**; the PCB **130** contacts the electrical interposer **120**; and the electrical interposer **120** contacts the package **112**. The top surface of package **112** that is external to the chip also contacts the clamp plate **150**. The package **112** is attached to the IC chip **110**; however, the IC chip **110** passes through the clamp plate window and therefore does not contact the clamp plate **150**. The IC chip **110** is therefore not included in the first clamped group of components.

The studs **142** are connected to the backing plate **140** and pass through apertures in the PCB **130** and clamp plate **150**. The first group of clamped components between the clamp plate **150** and the backing plate **140** are clamped together through a first clamping assembly that connects onto the pair of studs **142A** and **142B**. The first clamping assembly consists of a pair of clamping pressure transfer bushings **258A** and **258B**, a pair of clamp springs **256A** and **256B**, and a pair of clamp nuts **254A** and **254B**.

Moving from the top of the first clamped group of components to the top of the entire clamping assembly **104**, the following components comprise a second group of clamped components: the IC chip **110** contacts the chip thermal interposer **114** (for example, a thin layer of grease or silicon); the chip thermal interposer **114** contacts a heat pipe **200**; the heat pipe **200** contacts a bonding material layer **205**; and the bonding material layer **205** bonds the heat pipe **200** to a heatsink. The heatsink includes a heatsink bottom plate **266**, a set of heatsink fins **264**, and a heatsink top plate **262**.

The studs **142** pass through apertures in the heat pipe **200**, the heatsink bottom plate **266** and the heatsink top plate **262**. The second group of clamped components is clamped together through a second clamping assembly that connects onto the pair of studs **142A** and **142B**. The second clamping assembly consists of a pair of inserts **270A** and **270B**, a pair of spring washers **272A** and **272B**, and a pair of clamp nuts **274A** and **274B**.

FIGS. **3A-3C** are a top view and two perspective views of a heatsink that requires **4** studs. FIG. **3A** includes two different vertical sliced views through the heatsink, in an embodiment of the present invention. FIG. **3B** includes a heat pipe **200**, a heatsink bottom plate **266**, a set of heatsink fins **264**, and a heatsink top plate **262**. FIG. **3C** is a vertical slice through the heatsink along the apertures **163A** and **163B**, illustrating the apertures **163** in the heatsink top plate **262**, the heatsink bottom plate **266**, and the heat pipe **200** that allow the studs to pass through the heatsink. FIG. **3C** also illustrates that the heat sink top plate **262** includes a set

of recessed cavities **263A** and **263B** around each aperture **163**, allowing the heat sink clamping assemblies to be recessed into the heatsink itself.

In FIG. **3A**, the heatsink is shown to include four apertures (**163A**, **B**, **C** and **D**) dimensioned to allow a set of four studs to pass through the heatsink for use in clamping together the clamping assembly. It will be evident to one of skill in the art that the clamping assembly may be designed to have different numbers of studs used for clamping. For example, in one embodiment, there is a pair of two studs. In another embodiment, a set of four studs is used. The number of apertures through the heatsink, PCB and clamp plate component of the clamping assembly corresponds to the number of studs used.

In one embodiment, the clamping assembly includes several different IC chips. In this embodiment, a single large heatsink removes heat from several different IC chips. The clamp plate contains several windows corresponding to the number of IC chips, or one large window to encompass all the chips, or any combination of windows between, dimensioned to allow an IC chip to pass through and contact the heatsink directly. The clamping assembly components are dimensioned to accommodate the area of several IC chips as well as the apertures used to allow the studs to pass through the clamping assembly.

Although the invention has been described in considerable detail with reference to certain embodiments, other embodiments are possible. As will be understood by those of skill in the art, the invention may be embodied in other specific forms without departing from the essential characteristics thereof. For example, different types of electrical circuit assemblies may be used within the invention. Additionally, a heat pipe may be included in the heatsink assembly. Accordingly, the present invention is intended to embrace all such alternatives, modifications and variations as fall within the spirit and scope of the appended claims and equivalents.

What is claimed is:

1. A heatsink clamping system for applying a force onto an electrical circuit assembly, comprising:
 - an electrical circuit assembly including an electrical circuit, the electrical circuit assembly having edges extending beyond the electrical circuit;
 - a printed circuit board electrically coupled to the electrical circuit assembly, the printed circuit board including a first set of apertures;
 - a set of studs connected to the printed circuit board and extending perpendicular to the plane of the printed circuit board, the set of studs extending through the first set of apertures in the printed circuit board;
 - a clamp plate in contact with the edges of the electrical circuit assembly, the clamp plate including a window larger than the electrical circuit, the clamp plate further including a second set of apertures for the set of studs to pass through the clamp plate; and
 - a heatsink in contact with the electrical circuit, the heatsink further including a third set of apertures for receiving the set of studs which pass through the heatsink.
2. The system of claim **1**, further including:
 - a set of clamp nut assemblies coupled with the studs for clamping the printed circuit board to the clamp plate.
3. The system of claim **1**, further including:
 - a set of clamp nut assemblies coupled with the studs for clamping the heatsink to the printed circuit board.

4. The system of claim 1, further including:
a backing plate in contact with the printed circuit board, wherein the backing plate connects the set of studs to the printed circuit board.
5. A heatsink clamping system for applying a controllable force onto an electrical circuit assembly, comprising:
an electrical circuit assembly including an electrical circuit, the electrical circuit assembly having edges extending beyond the electrical circuit;
a printed circuit board electrically coupled to the electrical circuit assembly, the printed circuit board including a first set of apertures extending through the printed circuit board;
a backing plate in contact with the printed circuit board, the backing plate coupled to a set of studs extending perpendicular to the plane of the backing plate, the set of studs extending through the first set of apertures in the printed circuit board;
a clamp plate in contact with the edges of the electrical circuit assembly extending beyond the electrical circuit, the clamp plate further including a window extending through the clamp plate and a second set of apertures extending through the clamp plate, the window larger than the electrical circuit, the second set of apertures for allowing the set of studs to pass through the clamp plate;
a heatsink in contact with the electrical circuit, the heatsink further including a third set of apertures for receiving the set of studs which pass through the heatsink;
a first set of clamp nut assemblies coupled with the studs for clamping the backing plate to the clamp plate; and
a second set of clamp nut assemblies coupled with the studs for clamping the heatsink to the backing plate.
6. The system of claim 5, wherein the electrical circuit assembly includes:
an electrical circuit;
a package electrically coupled to the electrical circuit, the edges of the package extending beyond the electrical circuit; and
an electrical interposer electrically coupled to the package, wherein the electrical interposer further electrically couples the package to the printed circuit board.
7. The system of claim 6, wherein the package material is one from the group comprising: ceramic, plastic, or laminate.
8. The system of claim 6, wherein the electrical interposer is a carrier including embedded conductive elements.
9. The system of claim 8, wherein the carrier material is one from the group comprising: a polyimide film, a ceramic or a polymer.
10. The system of claim 8, wherein the conductive element material is either gold-plated or silver-plated copper.
11. The system of claim 8, wherein the conductive element material is either gold-plated or silver-plated molybdenum.
12. The system of claim 8, wherein the conductive element material is either gold-plated or silver-plated beryllium.
13. The system of claim 6, wherein the electrical circuit is an integrated circuit chip.
14. The system of claim 13, wherein the integrated circuit chip is a flip chip.
15. The system of claim 5, further including:
a thermal interposer layer thermally coupling the electrical circuit and the heatsink, wherein the thermal interposer layer is dimensioned to cover the electrical circuit.

16. The system of claim 15, wherein the thermal interposer layer is either thermally conductive grease or a thermal epoxy.
17. The system of claim 15, further including:
a heat pipe thermodynamically coupling the thermal interposer layer and the heatsink.
18. The system of claim 17, wherein the surface of the heat pipe in contact with the heatsink is coated with a bonding material.
19. The system of claim 5, wherein the heatsink comprises:
a heatsink upper plate;
a heatsink lower plate; and
a plurality of heatsink fins, wherein each heatsink fin is a plane perpendicular to the heatsink upper and lower plates and extends between the heatsink lower plate and the heatsink upper plate.
20. The system of claim 5, wherein the set of clamp nut assemblies dimensioned to fit the studs for clamping the backing plate to the clamp plate includes clamping pressure transfer bushings.
21. The system of claim 5, wherein the set of clamp nut assemblies dimensioned to fit the studs for clamping the heatsink to the backing plate includes a nut and spring washer.
22. The system of claim 5, wherein the clamp plate material is steel.
23. The system of claim 5, wherein the backing plate material is steel.
24. The system of claim 5, wherein the heatsink material is aluminum.
25. The system of claim 5, wherein the heatsink material is copper.
26. The system of claim 5, wherein the heatsink material is an impregnated polymer.
27. The system of claim 5, wherein the clamp plate is approximately the same thickness as the electrical circuit.
28. The system of claim 5, wherein the electrical circuit assembly includes a plurality of electrical circuits.
29. The system of claim 28, wherein the clamp plate includes a plurality of windows.
30. A clamping mechanism, comprising:
an electrical circuit assembly including at least one electrical circuit, the electrical circuit assembly having edges extending beyond the electrical circuit;
a printed circuit board electrically coupled to the electrical circuit assembly;
a clamping means for applying a first force onto the electrical circuit assembly, the clamping means mechanically coupled to the printed circuit board, and
a thermally conductive means for applying a second force onto at least one electrical circuit, wherein the thermally conductive means are thermally coupled with at least one electrical circuit, said thermally conductive means further mechanically coupled to the printed circuit board.
31. The clamping mechanism of claim 30, further comprising:
a set of studs extending perpendicular to the plane of the printed circuit board;
a set of clamp nut assemblies configured to fit the studs for mechanically coupling the clamping means to the printed circuit board; and
a second set of clamp nut assemblies configured to fit the studs for mechanically coupling the thermally conductive means to the printed circuit board.

11

32. The clamping mechanism of claim **31**, wherein the clamping means comprises a set of apertures configured to allow the set of studs to pass through the clamping means.

33. The clamping mechanism of claim **31**, wherein the thermally conductive means comprises a set of apertures 5 configured to allow the set of studs to pass through the thermally conductive means.

34. The clamping mechanism of claim **30**, wherein the clamping means is configured to apply the first force onto the edges of the electrical circuit assembly. 10

35. The clamping mechanism of claim **30**, wherein the at least one electrical circuit comprises four sides.

36. The clamping mechanism of claim **35**, wherein the clamping means further comprises a window.

37. The clamping mechanism of claim **36**, wherein the window bounds all sides of the at least one electrical circuit. 15

38. The clamping mechanism of claim **37**, wherein the window is circular.

39. The clamping mechanism of claim **36**, wherein the window bounds three sides of the at least one electrical circuit. 20

40. The clamping mechanism of claim **30**, wherein the clamping means further comprises a window.

41. The clamping mechanism of claim **40**, wherein the window bounds all sides of the at least one electrical circuit.

12

42. A clamping system, comprising:

an electrical circuit assembly including at least one electrical circuit;

a printed circuit board electrically coupled to the electrical circuit assembly;

a clamp plate for applying a first force onto the electrical circuit assembly, the clamp plate in contact with the electrical circuit assembly; and

a heatsink thermally coupled to the at least one electrical circuit, the heatsink further mechanically coupled to the printed circuit board and configured to apply a second force onto the at least one electrical circuit.

43. The clamping system of claim **42**, wherein the clamp plate further includes a window.

44. The clamping system of claim **43**, wherein the window bounds all sides of the at least one electrical circuit.

45. The clamping system of claim **1**, wherein the window bounds all sides of the electrical circuit.

46. The clamping system of claim **1**, wherein the window bounds three sides of the electrical circuit.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,459,582 B1
DATED : October 1, 2002
INVENTOR(S) : Hassan O. Ali and Richard L. Bechtel

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 12,

Delete lines 1 through 20,

“42. A clamping system, comprising:

an electrical circuit assembly including at least one electrical circuit;
a printed circuit board electrically coupled to the electrical circuit assembly;
a clamp plate for applying a first force onto the electrical circuit assembly,
the clamp plate in contact with the electrical circuit assembly; and
a heatsink thermally coupled to the at least one electrical circuit, the
heatsink further mechanically coupled to the printed circuit board and
configured to apply a second force onto the at least one electrical circuit.

43. The clamping system of claim 42, wherein the clamp plate further
includes a window.


44. The clamping system of claim 43, wherein the window bounds all sides
of the at least one electrical circuit.

45. The clamping system of claim 1, wherein the window bounds all sides
of the electrical circuit.

46. The clamping system of claim 1, wherein the window bounds three
sides of the electrical circuit.”

Signed and Sealed this

Fourth Day of February, 2003



JAMES E. ROGAN

Director of the United States Patent and Trademark Office